THE PHYSIOLOGICAL AGE STRUCTURE OF AN *AEDES SOLLICITANS* POPULATION IN NEW JERSEY.[1]

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ABSTRACT. A parity profile on an *Aedes sollicitans* (Walker) population in New Jersey revealed that the physiological age structure varied considerably over the course of a season. A total of 2,067 specimens collected at weekly intervals over a 2-year period revealed 957 nulliparous, 959 1-parous, 131 2-parous and 20 3-parous mosquitoes. Multiparous specimens were most common in the later portion of the season in both years. Mosquitoes which had completed 2 gonotrophic cycles were not collected until early July and 3-parous *Ae. sollicitans* were not collected until mid August. By early September, multiparous specimens made up more than 10% of the collections in 1974 and nearly 17% in 1975. The physiological age structure of the population also varied in collections made at different distances inland from the salt marsh/upland ecotone. Nulliparous specimens predominated at the sites farthest inland and multiparous mosquitoes were most commonly collected closer to the salt marsh.

INTRODUCTION

Aedes sollicitans (Walker), the common salt marsh mosquito, is an extremely important pest species along much of the Atlantic seaboard. The coastal wetlands of New Jersey provide a vast expanse of suitable breeding habitat for *Ae. sollicitans* and multiple broods are produced each year. Headlee (1945) has documented the economic importance of this mosquito with particular reference to its impact on the coastal resort areas of southern New Jersey. In recent years, *Ae. sollicitans* has also been recognized as an important vector of human disease in the State.

In a description of the 1959 outbreak of eastern encephalitis in New Jersey, Goldfield and Sussman (1968) reported that all 32 human cases occurred in persons who had visited or resided in the southern counties of the State. Hayes et al. (1962) showed that *Ae. sollicitans* was the dominant mosquito during the outbreak and hypothesized that the species served as the primary epidemic vector in the coastal area where most of the human cases occurred. Crans (1977) has since summarized the evidence for vector involvement and concluded that *Ae. sollicitans* must be regarded as an epidemic vector of eastern encephalitis in New Jersey.

Although *Ae. sollicitans* is a serious pest and an important vector of disease, relatively little is known of the age structure of wild populations. Since the physiological age of the vector population has a direct influence on vector potential, age-grading studies are needed to better define the role of *Ae. sollicitans* in the transmission of disease. Crans et al. (1976) have shown that the physiological age of an *Ae. sollicitans* population may vary according to distance from the breeding marsh and suggest that the vector potential is greatest in areas close to a breeding source. Their studies, however, were based solely upon parous rates and did not consider the number of gonotrophic cycles completed by the female mosquito.

During the summers of 1974 and 1975, a study was made to determine the seasonal parity profile of an *Ae. sollicitans* population according to the number of

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gonotrophic cycles that the females had completed and to determine if parity varied with distance from the breeding marsh. The results of this study are presented in this paper.

MATERIALS AND METHODS

Studies were conducted near the town of Barnegat in Ocean County, New Jersey. Two roads, 1.9 km apart, provided transects that ran directly from the salt marsh to the upland (Fig. 1). On each transect, 3 open fields were selected as sampling stations for adult mosquitoes. The first transect, Taylor Road (39° 43′ 30″ N, 74° 14′ 10″ W) was examined from June to September in both 1974 and 1975. The 3 sampling stations (A, B & C) were located at 0, 1.3, and 2.9 km from the salt marsh/upland ecotonal edge. The second transect, Lower Shore Road (39° 44′ 45″ N, 74° 13′ 45″ W) was examined from June to September in 1975 only. The 3 sampling stations (A′, B′ & C′) were located at 0, 1.4 and 2.4 km from the salt marsh/upland ecotonal edge.

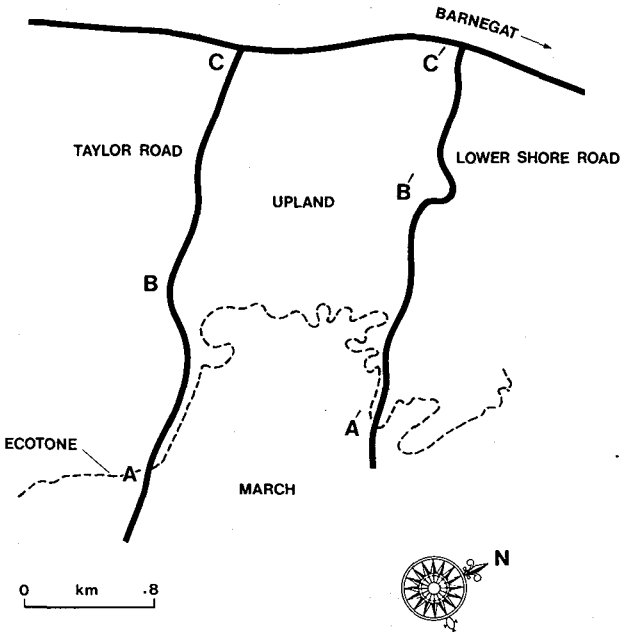

Fig. 1. Map of the study area in Ocean County, New Jersey and the 6 sampling stations along Taylor Road and Lower Shore Road.

Sampling was conducted between 1030 and 1300 hrs once weekly in both years. Collections were made at each of the sampling stations in a marsh to upland direction on one date and the reverse on alternate dates. Female mosquitoes were attracted from their resting places as the investigator walked slowly through the vegetation in the fields. Mosquitoes coming to bite were collected with a mouth aspirator and placed in cardboard ice cream containers. The collection from each sampling station was immediately killed on dry ice in the field and transferred to 4 dram snap cap vials. In 1974, single collections of 10–15 mosquitoes per station were made. In 1975, 2 replications were made at each site over 10-minute intervals. Specimens were returned to the laboratory on dry ice and frozen for up to 3 weeks prior to dissection.

A New Jersey light trap was operated nightly at station B on Taylor Road from May to October in both 1974 and 1975 by the Ocean County Mosquito Commission. The data were used to determine the number of broods that were produced during the period of investigation and the relative numbers of adults in both years.

Mosquitoes were dissected on a microscope slide in a small drop of distilled water at 30X stereoscopic magnification. A small slit was made in the tip of the mosquito abdomen with minuten probes and the ovaries were removed by applying gentle traction to the tip of the abdomen.

All specimens were first examined by Detinova's method of ovarian tracheolation (Detinova 1962) to determine whether or not the mosquito had oviposited. One ovary from each of the females was removed to a separate microscope slide and air dried at room temperature. When completely dry, the slide was examined at 150X to determine the condition of the tracheoles. Coiled tracheoles were used as an indication of nulliparity; stretched and unwound tracheoles indicated a parous specimen.

Nulliparous specimens were not examined further but in parous mosquitoes the opposite ovary was examined for dilatations by the method of Polovodova (1949) to determine the number of gonotrophic cycles that the specimen had completed. The entire ovary was transferred to a drop of distilled water and the ovarian sheath was removed. The individual ovarioles were teased apart with minuten probes and the pedicels were examined for dilatations. Subdued light and a magnification of 100X on a stereomicroscope were necessary for accurate examination. In most cases, the count was confirmed by removing the entire ovariole with pedicel intact for direct examination at 10X5 or higher under compound magnification. Several ovarioles were examined from each ovary before the number of gonotrophic cycles was recorded.

RESULTS AND DISCUSSION

NUMBER OF BROODS IN THE STUDY AREA. The daily light trap data plotted on a 5-point moving mean and weekly parity data from mosquitoes collected at station B are presented in Figure 2. Five major broods were evident during the period of investigation in 1974 with peak emergences occurring in mid June, early July, early August, mid August and early September (Fig. 2A). Four major broods occurred during the investigation in 1975 with peak emergences in late May, late June, mid July and late August (Fig. 2B). The July brood was the largest of the season in both years. Large numbers of mosquitoes from the July brood were present for most of the month in 1975 as a result of frequent, repeated floodings and asynchronous mosquito emergences during that unusually wet period.

AGE COMPOSITION OF THE BITING POPULATION. A total of 2067 *Ae. sollicitans* were age-graded from the study area in the 2 years that collections were performed. The results of the dissections are presented in Table 1. In 1974, 1248 dissections revealed 615 nulliparous, 557 1-parous, 67 2-parous and 9 3-parous mosquitoes. Nulliparous and 1-parous specimens made up the vast majority of the mosquitoes in the collection; 2-parous

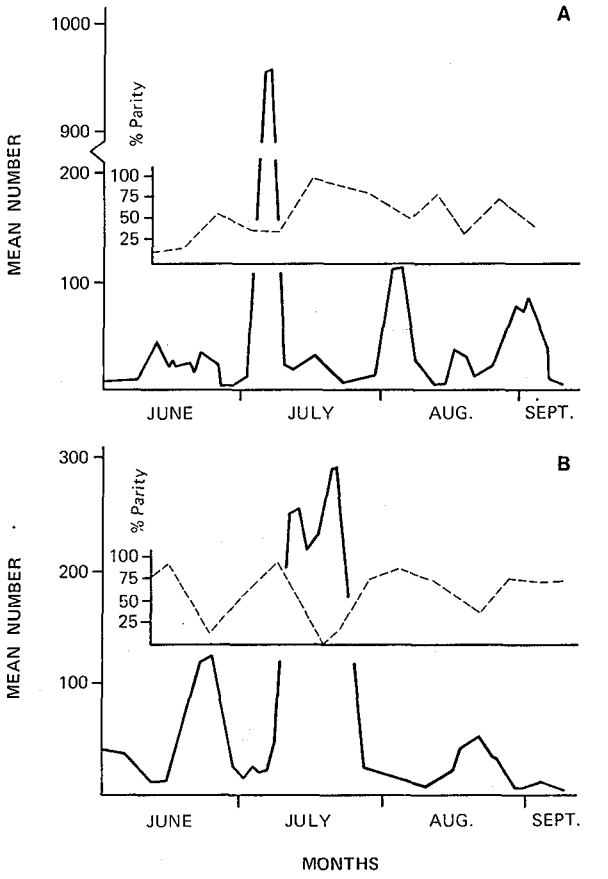

Fig. 2. The numbers of *Aedes sollicitans* collected by light trap at station B on Taylor Road and the parous rates obtained by ovarian dissection (A., 1974 collections; B., 1975 collections).

and 3-parous specimens accounted for only 5.4 and 0.7% respectively of those which were examined.

A similar pattern was exhibited in 1975 when 819 *Ae. sollicitans* were age-graded. No significant differences were found between the 2 transects, thus, data have been combined in Table 1. Dissections revealed 342 nulliparous, 402 1-parous, 64 2-parous and 11 3-parous mosquitoes.

Data in Table 1 indicate that a relatively large proportion of the *Ae. sollicitans* population completes one gonotrophic cycle but relatively few oviposit 2 or more times. Most of the mosquitoes collected were either nulliparous or 1-parous and when viewed over the course of an entire season, these 2 age groups were collected in near-equal numbers. Nulliparous specimens predominated shortly after a brood emerged but an increasing percentage of 1-parous mosquitoes were collected by the following week. As the parous rate increased in subsequent weeks, nearly all of the specimens had oviposited. The percentage of nulliparous and 1-parous specimens collected in any given month showed considerable variation since aging usually overlapped the artificial time blocks used. The percentage of nulliparous and 1-parous mosquitoes in the collections for the entire season, however, were remarkably similar.

Throughout the course of these investigations, multiparous mosquitoes were most numerous in the later portion of the season. No 2-parous *Ae. sollicitans* were collected in June of either year. Cool temperatures in the early portion of the season may have been a factor by slowing down the gonotrophic process. Mosquitoes which had completed 2 gonotrophic cycles were not collected until early July in both years and 3-parous *Ae. sollicitans* were not collected until mid August. By September, multiparous specimens made up more than 10% of those collected in 1974 and nearly 17% of those collected in 1975.

The abundance of multiparous *Ae. sollicitans* late in the season is supportive of this mosquito's involvement in human outbreaks of eastern encephalitis. Goldfield and Sussman (1968) indicated that human cases were first reported in late August during the 1959 outbreak of EE in New Jersey. Crans et al. (1976) found that the vector potential of *Ae. sollicitans* was extremely high during the later portion of the season at another site in Ocean County, New Jersey. Data from the present study showed that the cumulative

Table 1. Monthly age structure of *Ae. sollicitans* collections at Taylor Road and Lower Shore Road transects near Barnegat, New Jersey in 1974 and 1975.

Month	Age group [1]							
	Nulliparous		1-Parous		2-Parous		3-Parous	
	1974 [2]							
June	191	(70.0)	82	(30.0)	—		—	
July	196	(38.8)	285	(56.3)	25	(4.9)	—	
August	159	(43.8)	164	(45.2)	35	(9.6)	5	(1.4)
September	69	(65.1)	26	(24.5)	7	(6.6)	4	(3.8)
	1975 [3]							
June	75	(41.7)	105	(58.3)	—		—	
July	158	52.8)	119	(39.8)	22	(7.4)	—	
August	80	(34.5)	117	(50.4)	29	(12.5)	6	(2.6)
September	29	(26.9)	61	(56.5)	13	(12.0)	5	(4.6)

[1] Number of specimens according to age group followed by percentage in parentheses.
[2] Taylor Road transect only.
[3] Taylor Road and Lower Shore Road transects combined.

parity of *Ae. sollicitans* collected from mid August to early September was approximately 70% in both years with 1, 2 and 3-parous mosquitoes represented. This suggests a mosquito population capable of transmitting a virus to man if a source of infection were available.

AGE COMPOSITION VERSUS DISTANCE FROM THE MARSH. When physiological age dissections were grouped according to distance from the salt marsh, differences in the age composition of the collections became evident. Table 2 lists the results of the physiological age dissections according to station along the 2 transects examined in these studies. An analysis of variance of the 1975 data and a multiple regression analysis of the combined 1974 and 1975 data indicated statistically significant differences ($P = .001$, where $P = F$ value observed) for all age groups by station. There was no significant difference between collections from the 2 transects.

At the stations closest to the salt marsh (A & A') parous *Ae. sollicitans* made up 64–77% of the specimens in the collections and all of the age classes were represented. At the stations farthest from the salt marsh (C & C'), nulliparous *Ae. sollicitans* formed the predominant age class and no 3-parous mosquitoes were collected. Collections from the intermediate stations (B & B') contained specimens from all age classes with no clear predominance of nulliparous or parous mosquitoes. Data indicated that the older mosquitoes, particularly those which had completed 2 or more gonotrophic cycles were most prevalent within 1.4 km of the salt marsh/upland ecotone.

These results support the findings of Crans et al. (1976) who suggested that parous *Ae. sollicitans* rest and feed closer to a breeding marsh than their nulliparous counterparts. In their studies, a combination of landing rates and parity dissections showed that a relatively small percentage of the parous population returned as far inland as 2 mi. (3.2 km.) in quest of a blood meal. Data from the present study help define the distance traveled by parous and multiparous *Ae. sollicitans*. While no landing rates were conducted to quantify nuisance at the 3 distances, data indicate that the age structure of the populations does change according to distance from the breeding marsh.

Table 2. The variability in physiological age of *Ae. sollicitans* collected at various distances from the marsh/upland ecotone in 1974 and 1975.

Station	Distance (km)	Age Group [1]							
		Nulliparous		1-parous		2-parous		3-parous	
		1974							
A	0	151	(35.6)	231	(54.5)	35	(8.3)	7	(1.6)
B	1.4	213	(52.6)	167	(41.2)	23	(5.7)	2	(0.5)
C	2.9	251	(59.9)	159	(38.0)	9	(2.1)	0	—
		1975 [2]							
A	0	34	(24.6)	79	(57.3)	20	(14.5)	5	(3.6)
B	1.4	58	(41.4)	73	(52.1)	8	(5.7)	1	(0.7)
C	2.9	79	(57.2)	56	(40.6)	3	(2.2)	0	—
		1975 [3]							
A'	0	31	(23.0)	81	(60.0)	20	(14.8)	3	(2.2)
B'	1.3	58	(43.3)	64	(47.8)	10	(7.5)	2	(1.5)
C'	2.4	82	(61.2)	49	(36.6)	3	(2.2)	0	—

[1] Number of specimens according to age group followed by percentage in parentheses.
[2] Taylor Road transect.
[3] Lower Shore Road transect.

CONCLUSIONS

When viewed over the course of an entire season, the physiological age composition of an *Ae. sollicitans* population shows considerable variation. Data suggest that old parous mosquitoes are most numerous in the later portion of the breeding season and are also more commonly collected within 1.4 km. of their breeding habitat. These findings may be of value in virus surveys during periods of epizootic or epidemic eastern encephalitis activity. Morris and DeFoliart (1971) suggested that virus surveys should be conducted when the parous rate of the population is increasing to save time and expense in the survey procedure. Data from the present study suggest that sampling of *Ae. sollicitans* should be conducted close to a breeding source to sample the oldest portion of the population. Late season populations would have the greatest probability of containing virus since a greater proportion of the populations has acquired multiple blood meals.

The parity profile of the *Ae. sollicitans* collected in these studies provides insights to the behavior of the species. Additional virus isolation studies, however, are necessary to better define the role of *Ae. sollicitans* in the transmission of disease.

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References Cited

Crans, W. 1977. The status of *Aedes sollicitans* as an epidemic vector of eastern equine encephalitis in New Jersey. Mosquito News 37(1):85–89.

Crans, W., J. Downing and M. Slaff. 1976. Behavioral changes in the salt marsh mosquito, *Aedes sollicitans* as a result of increased physiological age. Mosquito News. 36(4):437–445.

Detinova, T. 1962. Age-grouping methods in Diptera of medical importance. WHO Monograph No. 47:1–216.

Goldfield, M. and O. Sussman. 1968. The 1959 outbreak of eastern encephalitis in New Jersey. 1. Introduction and description of outbreak. Amer. J. Epidemiol. 87(1):1–10.

Hayes, R., L. Beadle, A. Hess, O. Sussman and M. Bonese. 1962. Entomological aspects of the 1959 outbreak of eastern encephalitis in New Jersey. Amer. J. Trop. Med. & Hyg. 11(1):115–121.

Headlee, T. 1945. The mosquitoes of New Jersey and their control. Rutgers Univ. Press, New Brunswick, N.J. 326 pp.

Morris, C. and G. Defoliart. 1971. Parous rates in Wisconsin mosquito populations. J. Med. Entomol. 8(2):209–212.

Polovodova, V. 1949. Determination of the physiological age of female *Anopheles*. Meditsinskaia Parasit. Moscow. 18:352–359 (In Russian).